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CHANGES IN MILK DELIVERY COSTS AND VOLUME-PRICING PROCEDURES IN CALIFORNIA

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SUMMARY

This report primarily is concerned with an analysis of the differentials in delivery costs associated with varying volumes per stop in the Los Angeles market and with an appraisal of the effectiveness of recently introduced volume-pricing procedures in reflecting these cost differentials. Delivery cost-volume relationships were calculated for this market in 1950 in an intensive analysis of wholesale milk delivery routes.

Milk prices in California markets are established, at all levels of the marketing system, by the Bureau of Milk Stabilization, a state agency. Prior to May 10, 1956, milk prices in the Los Angeles marketing area were set on a uniform basis among all customers of the same type. On that date, the schedules of minimum wholesale and minimum retail prices for that market were amended to provide for a sliding price scale based on the quantity delivered. The schedule provided price results reasonably comparable to the cost differentials found in the 1950 analysis.

Since the original study, conditions affecting delivery-time requirements have changed. Changes have resulted directly from the adoption of volume-pricing procedures in this market. The number and size of retail food outlets have altered. Changes have occurred in the types and amounts of services rendered store customers by milk deliverymen and in the traffic densities and other driving conditions. Because of these assumed changes, the Bureau requested a re-examination of delivery costs as a means of establishing a better basis for its price orders. Therefore, the University of California undertook an analysis of a sample of wholesale milk delivery routes during the summer of 1959. The cost data collected in the more recent study were essentially the same kind as those obtained during 1950; however, the 1959 sample contained only about 25 per cent of the number of observations in the 1950 analysis. The method of analysis was the same as that used in the 1950 study. Finally, empirical analyses were made to determine what changes would be required to make the results of the 1950 analysis more closely representative of current conditions of wholesale milk delivery operations.

Three major conditions affecting delivery-time requirements in the Los Angeles markets changed sufficiently in the period between 1950 and 1959 to warrant a change in the basic time-volume relationship. First, an increased number of freeways and other new roads resulted in a decrease in driving-time

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requirements per mile. Second, the amount of driving time associated with each customer stop increased. Third, in 1950, it was relatively uncommon for the milk driver to service the customer's dispensary or icebox (display case). By 1959, however, these services were provided in about 75 per cent of the deliveries to customers classified as groceries and markets. Because this additional service appeared to be "typical" of current operations, appropriate adjustments for its inclusion were made to the relationship describing direct delivery-time requirements.

Wholesale milk delivery costs of a variable nature consisted of two elements: labor costs (accounting for more than 75 per cent of the total) and truck operating expenses. In California markets, labor costs were fixed on a daily basis by union wage agreements. In Los Angeles, these labor costs amounted to $29.73 per route day. Truck operating costs per route day varied directly with load sizes.

Delivery costs per quart were a function of delivery costs per route day and the volume of milk delivered per route day. Differentials in delivery costs per unit associated with variations in volumes per stop stemmed from differences in one or both of the above factors. Using the formulas determined in this report, the differential route volumes that could be achieved with different average delivery volumes have been calculated. Total delivery costs per route day appropriate for these load sizes have also been derived. As a result, it was estimated that delivery costs in the Los Angeles area decreased from nearly 6 1/2 cents per quart with a volume of 10 units per customer delivery to 1 3/4 cents per quart with an average volume of 100 units and continued to decline, but at a decreasing rate, to approximately 3/4 cent per quart with a volume averaging 1,000 units per customer.

These differential costs--which constitute the analytical core of this study--have been used to evaluate the effectiveness of the current volume-pricing schedule. The pricing schedule in early 1959 tended to be lower than costs for low-volume delivery ranges--particularly for deliveries of 49 units or less; but, for deliveries in excess of 200 units per stop, effective prices exceeded costs. On September 1, 1959, the schedule of minimum wholesale and minimum retail prices for fluid milk in the Los Angeles marketing area was amended to provide for an additional 2 per cent discount on any amount with a value in excess of $100 in a single delivery. In the range of delivery volumes above 50 units per stop, effective prices are still above calculated costs, although the "gap" has been narrowed for deliveries of 500 units or more.

Due to the nature of the cost-volume relationship, two separate discount systems based on the volume of milk actually delivered would be required to effect prices close to the costs. The "breaking point" between these two schedules occurred at a volume of 236 units. For deliveries of less than this amount, a base price of 20.5 cents per quart, subject to a discount of 7 per cent on any amount with a value over $7, was appropriate; and for deliveries of more than 236 labor units, a base price of 20.5 cents per quart, subject to a discount of 10 per cent on any amount with a value of more than $20, closely approximated costs.

Finally, comparative statistics on route volumes were obtained for the period just prior to the adoption of volume-pricing programs in seven California markets and for the period following the change in pricing system. The average volume per delivery and the average route volumes increased. Conditions affecting changes in such characteristics as route volumes, other than the change in pricing system, were not considered; therefore, it was impossible to ascribe this improvement in efficiency as a <u>net</u> effect of the volume-pricing program. At the same time, however, the improved efficiency reduced delivery costs substantially. In the Los Angeles market, delivery costs per unit fell 12 1/2 per cent, an average of 2/10 cent per quart. When applied to the total daily volume of milk sold at wholesale in the Los Angeles market, the reduction meant a cost saving of nearly $3,000 per delivery day.

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CHANGES IN MILK DELIVERY COSTS AND VOLUME-PRICING PROCEDURES IN CALIFORNIA

by

Olan D. Forker[1] and D. A. Clarke, Jr.[2]

Introduction

In California, prices for fluid milk--at all levels of the marketing system--are set by state agency. Under the provisions of the Agricultural Code of California,[3] the Director of Agriculture is authorized to designate minimum wholesale and retail prices for fluid milk. Similar established prices for fluid cream and for fluid skim products are optional. The California milk price control law is then administered and enforced by the Bureau of Milk Stabilization.

The Agricultural Code further specifies that for purposes of establishing minimum milk prices, the state shall be divided into "marketing areas" within which "the production, distribution, and sale of milk are reasonably uniform." In recent years, some of the previously designated marketing areas have been consolidated. In 1955, for example, there were 37 such areas; by 1960, this number had been reduced to 28. Of the latter, four marketing areas are divided into separate "zones." The Redwood, San Bernardino-Riverside, and Shasta-Tehama marketing areas each include two zones, while the Sacramento marketing area consists of three zones. In these segmented marketing areas, minimum resale prices were differentiated between zones, effectively increasing the number of areas with separately established resale prices from 28 to a total of 33.

For many years, minimum resale prices in California markets were established uniformly among all customers of the same type. No provision was made for discounts or other allowances for the differential costs in serving different types or sizes of delivery. As a result of this pricing policy, incentives or

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2/ Professor of Agricultural Economics, University of California, Berkeley.

3/ California, Agricultural Code of California (1953), c. 17, div. 6, "Stabilization and Marketing of Fluid Milk and Fluid Cream."

"pressures" were created to by-pass the effective enforcement of the minimum price schedules.

In 1950, the Giannini Foundation was requested to undertake studies of the differential costs of large- versus small-volume deliveries of milk and, from such studies, to make suggestions for alternative pricing schedules reflecting these cost differentials. These analyses were made during the period 1950-1954. Wholesale milk delivery routes were studied in all of the major markets of the state, including Los Angeles, San Francisco, Alameda-Contra Costa, Sacramento, San Diego, Fresno, and Stockton. A total of 272 wholesale routes operated by 48 processing plants in these 7 markets were ridden and observed. In addition, detailed time studies were made on 113 retail routes in the Los Angeles and Fresno markets.[1/]

As the results of these studies became available, milk price hearings were held in these marketing areas. Subsequent amendments to the minimum wholesale and minimum retail price schedules contained provisions for volume pricing.

Wholesale Pricing Programs

This category of prices includes all sales of fluid milk for resale purposes--to customers such as groceries, restaurants, schools, and institutions. Historically, a single-price schedule has applied to all customers within this group.

In the period between the fall of 1956 and the spring of 1957, wholesale volume-pricing schedules were put into effect in the following 11 marketing areas: Alameda-Contra Costa, San Francisco, Santa Clara, Sacramento, San Joaquin, Fresno, Los Angeles, Orange, San Bernardino-Riverside, San Diego, and Kern.

Two types of volume-pricing procedures were employed in these markets. For purposes of comparison, they are categorized as either the "continuous" type or the "bracket" type. Each of these types of volume-pricing procedures involves the stipulation of a base price. Under the continuous type procedure, a stated discount (usually specified in percentage terms) may be applied only to those sales made in a single delivery in excess of a given quantity (normally expressed

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1/ The results of this research and suggested alternative price plans are presented in D. A. Clarke, Jr., Milk Delivery Costs and Volume Pricing Procedures in California, California Agricultural Experiment Station Bul. 757 (Berkeley, 1956), 77p.

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in dollar value terms). This procedure has also been referred to as an exclusion procedure, since a certain portion of each delivery is excluded from discount.

The bracket form of volume pricing is the more familiar form of volume discount. Sales in a single delivery are subject to a schedule of percentage discounts that can be applied to various brackets of quantities purchased. With the exception of one area (Kern County), three brackets are used.1/ Again, the discounts are stated in percentages, while the quantities to which they apply are measured in dollar terms.

Illustrations of these two types are given in Figures 1-A and 1-B. These present hypothetical effective prices under the alternative systems. The continuous type of program--Figure 1-A--indicates that a flat or uniform price applies to all sales up to quantity Q_1. This quantity is the excluded portion of the delivery. Since sales in excess of the quantity Q_1 are subject to discount, the effective prices for the larger deliveries decline in a continuous fashion but at a decreasing rate.2/

The bracket type of volume-pricing procedure is illustrated in Figure 1-B. As shown, the base or net price is effective for all sales involving deliveries of Q_1 or less. For milk deliveries in larger amounts than Q_1 but less than Q_2, the second bracket (smaller discount) becomes effective. This discount is effective on the total volume delivered. Where customer requirements are in excess of Q_2, the third bracket (largest discount) becomes applicable. Relatively speaking, the base price is higher and the discount percentage smaller under a bracket procedure than under the continuous type of pricing system.

Originally, the continuous type schedules were adopted in 7 of the 11 areas where volume pricing was made effective. Industry objection to the use of this type of procedure was encountered in some areas. For one thing, this system was not as familiar to the trade as the bracket system and therefore was more difficult to understand and to explain to customers. In addition, the complaint arose

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1/ In the Kern County marketing area, four brackets are effective.

2/ This curve is a parabolic function, asymptotic to the line (not shown) that would represent the average discounted price. The function that would represent the total value of deliveries of varying sizes (comparable with a "total revenue" function) would be "kinked," since it is made up of two-line segments of different slopes. In this case, the kink would be "downward," since that part of the function relevant to smaller deliveries would be of steeper slope than the segment corresponding to the right-hand side of the point Q_1.

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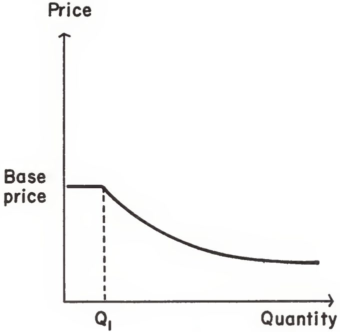

Figure 1-A. Example of "Continuous" Volume-Pricing Procedure

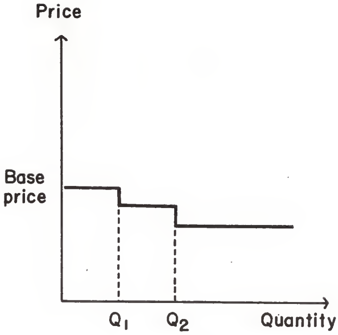

Figure 1-B. Example of "Bracket" Volume-Pricing Procedure

that this system provided an incentive for customers to overstock, thus increasing the amount of packaged milk that had to be returned to the plant for salvage. As a result, three markets initially adopting a continuous type of wholesale volume-pricing procedure subsequently shifted to the bracket version.

Retail Volume-Pricing Programs

Volume pricing at retail or home-delivered levels has existed longer in California than it has for the wholesale level, although the former is not quite as widespread. Retail volume-pricing programs became effective in the Alameda-Contra Costa County marketing area and in some southern California markets (including Los Angeles) during the latter part of 1952. Presently, such programs are in effect in nine of the state's marketing areas. These are: Alameda-Contra Costa, Del Norte-Humboldt, Fresno, Los Angeles, Sacramento (Zone 1), San Bernardino-Riverside, San Francisco, San Joaquin, and Solano.

Two types of volume-pricing programs are again employed. A bracket system similar to that used in wholesale price schedules is used in four markets; however, the discount normally is stipulated in terms of a price reduction in cents per quart and the brackets specified in terms of quarts of milk delivered. A "service-charge" procedure is in effect in the four remaining markets. Under this procedure, a flat amount (3 cents in the San Francisco area and 4 cents in the other markets using this procedure) is added to the basic retail home-delivered price. In the markets where the service-charge system is used, the base price is usually about the same as the out-of-store price.1/

The Need for Reanalysis

As previously mentioned, the volume-pricing programs now in effect were based largely upon research determination of cost-volume relationships. These studies measured the nature and magnitude of the differential costs associated with the various delivery sizes and provided a normative base for the establishment of a price schedule to reflect these differential costs.

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1/ In markets where no retail volume-pricing programs are used, the retail price ranges from 0.5 cent to 1.5 cents above the minimum store price. This difference is commonly termed the "store differential."

Since 1950, several changes have occurred in the conditions affecting delivery-time requirements. These include an increase in the number of large-scale retail food outlets--an important segment of the wholesale sales of fluid milk distributors. Changes have also transpired which are directly related to the volume-pricing procedure itself. Formerly, when faced with uniform or flat prices, regardless of quantities purchased, retail store management decided on the number of brands to be carried without a pricing "penalty" for expanding the number of distributors to serve the total milk requirements. Each additional distributor reduced the volume served per distributor so unit delivery costs were increased. Volume pricing per se, however, provides an incentive to retail management to limit the number of incoming deliveries while increasing their quantities to qualify for larger discount rates. Changes also have been reported in the types and amounts of services rendered the store customer by milk deliverymen. Finally, the increasing number of freeways and the changing traffic densities well may have influenced driving-time requirements.

In addition to the above factors--which may be expected to change the basic input-output function for delivery services--other institutional factors which affected the related retail outlet, milk processing industry structure have altered. The above-mentioned increase in numbers of large-scale retail food stores has resulted in increased pressures to expand the degree of integration. The greater importance of captive creameries, captive supermarkets, and other forms of vertical integration has had important cost and pricing implications. Possible errors in volume-pricing arrangements due to incomplete information about current cost-volume relationships may be one factor that stimulated this structural development.

In view of the above, it was decided to make a reanalysis of the basic cost data, including an investigation of the input-output delivery time-volume relations.

Objectives and Procedures

The purpose of the present study is: (1) to determine how changes that have occurred in the past decade have affected cost-volume relationships in wholesale milk delivery operations and (2) on the basis of this information, to evaluate the effectiveness of the present volume discount schedules established by the Bureau of Milk Stabilization in reflecting these differential costs.

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As mentioned earlier, the original studies made during the 1950-1954 period involved detailed information of wholesale milk route operations in seven of the major milk markets in California. Of the 272 wholesale routes studied, 111 served the Los Angeles market. Routes of ten companies were observed during the summer of 1950. Four of these companies were classified as "specialized," in that the ownership of the milk processing and distribution facilities were exclusively in the hands of the grocery stores or other outlets they serve. These companies serve only stores controlled by their stockholders, which, in general, are large-volume, low-cost outlets. The remaining six distributors were termed "independents," in that there was no necessary similarity of financial or managerial background between the dairy distributors and the customers they serve.1/

The total volume of dairy products delivered on the routes observed during the 1950 study amounted to approximately 30 per cent of the average daily volume of these products delivered at wholesale in the Los Angeles market during the month (June) in which the study was made. Observations were made of 2,897 individual customer deliveries, and all of the operations performed by the driver were noted and the amount of the elapsed time recorded.

In the reanalysis made during 1959, a total of 29 wholesale milk routes were ridden to obtain empirical data on time requirements. These included 25 routes of 4 independent companies and 4 routes of 4 specialized companies. Observations were made on 424 individual customer deliveries. The total products delivered by the 29 routes studied amounted to approximately 6 per cent of the average daily volume delivered in the Los Angeles marketing area during the month (July) in which the study was made.2/

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1/ There is reason to believe that the sample which was drawn is not representative in the sense that the number of observations in each of the various size groups and types of outlets which appear in the sample is proportional to the numbers in the universe. The vast majority of wholesale milk deliveries are of relatively small volumes, which means that the frequency distribution of delivery sizes is not only skewed to the left but that it "tails off" to the right with only a small percentage of the total number of observations having large-volume deliveries. With a proportional sample, therefore, the fewness of cases in this high-volume range will result in substantially less reliability for this range for any given sample size than will a sample which is disproportionately weighted by large-volume observations. For this reason, an effort was made to obtain as many large-volume delivery observations as possible.

2/ As was the case in the 1950 study, an effort was made to obtain observations on as many large-volume deliveries as possible. Therefore, the 1959 sample is again disproportionately weighted in terms of large-volume routes serving large-volume customers.

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Method of Analysis

Analytically, the costs of wholesale milk delivery consist of two elements--those expenses associated with delivery labor and those associated with truck operation. Of these two components, labor is by far the more important, accounting for nearly 75 per cent of the total cost of wholesale milk route operations.

Labor Costs

In California markets, wholesale milk delivery route labor costs per route day are established by wage agreement between union and management. In the Los Angeles markets during the summer of 1959, the labor expense per wholesale route day was determined to be $29.73. Wholesale milk routes in this area operate on a six-day, 48-hour route week basis. Regular drivers average 40 hours per five-day week. Overtime is paid at the rate of time-and-a-half for work in excess of 9 hours in any one day and for more than 40 hours per week. Relief drivers are all paid on the same basis but at a slightly higher hourly rate. Other labor costs include vacation replacements, sick leave, and unemployment and compensation insurance, as well as the cost of pension plans and health and welfare provisions. Details of these costs are given in Table 1. As an indication of the changes in labor costs in the Los Angeles market during the past decade, comparable calculations of labor costs per day were $18.65 in 1951 and amounted to $24.89 based on 1955 wage levels.

Since labor costs are fixed per day, variations in labor expense associated with deliveries of different volumes must derive from differences in total route volumes obtainable when large- versus small-volume customers are served. It is reasonable to expect that, all other things being equal, total time requirements on milk delivery routes will be a function of (1) the number of customers served, (2) the average volume of delivery made, and (3) the total quantity of products handled on the route. Other factors also influence time requirements, such as the distance covered by the route, the type of delivery services provided by the route salesman on the customer's premises, and various other institutional arrangements in the market. In the following analysis, the influence of these latter factors has been eliminated by holding them constant at magnitudes determined by average or typical conditions found in the market. The problem, therefore, in both the 1950 and the 1959 studies was to determine the nature and the extent of the relationships between the three variables--number of customers

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TABLE 1

Calculation of Wholesale Delivery Labor Costs Per Day
Los Angeles Market, 1959 Wage Rates

Items	Costs per week
	dollars
Regular drivers	120.00
Relief drivers	24.80
Foreman[a/]	6.50
Holidays and vacations	10.76
Pension plan and health and welfare fund	10.00
Compensation insurance and payroll taxes	6.32
Total expense per week	178.38
Delivery days per week	6
Labor expense per route day	29.73

a/ Based on 20 wholesale routes under each foreman.

served, average delivery volumes, and total route volumes--and time requirements for these operations.

In both studies, the approach to this determination was to break down total route-time requirements into three components which were then analyzed separately. These components included driving time, direct delivery time, and miscellaneous time.

Driving Time.--The amount of time spent in driving the delivery truck is a function of distance to be traveled and the rate of speed which can be maintained. The rate of speed, in turn, depends upon such factors as traffic and road conditions and the number of stops (either for traffic reasons or to service customers). The influence of road and traffic conditions was not included in the analysis, however, as such conditions are difficult to measure objectively. Also, no attempt was made to obtain information on the number of traffic stops for the corresponding time requirements. The results, therefore, represent average traffic conditions for the routes which were studied.

Differences were expected in the average rates of driving speed under the different conditions met in driving (1) from plant to route, (2) between customer stops while on the route, and (3) from route to plant. For this reason, data were obtained on the distance traveled between these points and the driving time consumed. In addition to the distance factor, the number of customer stops made by the driver was available and used in multiple correlation analyses of the time spent in driving between the first and last customer stop.

As stated in the objectives for this report, the 1959 reanalysis was made to test whether or not basic changes that had occurred in delivery methods had affected the underlying input-output relationships. A new network of freeways, for example, had sprung up around most of the markets which were involved. In some areas, union regulations had changed, which specified later delivery departure hours. Both of these changes might be expected to influence the average rate of driving speed and alter the coefficients relating to driving-time requirements.

Statistical techniques identical to those used in the 1950 study were applied to the 1959 data. These resulted in a new set of regression coefficients for each of the three subelements of the driving-time components. Each newly derived coefficient was then tested under the hypothesis that the 1959

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relationship was, in fact, equal to the 1950 relationship[1/] or that these coefficients determined from different samples were consistent with differences that might result from different samples drawn from the same population. In addition, a test was made to determine the homogeneity of regression between the corresponding relationship in the two time periods.[2/]

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1/ The test statistic for this hypothesis was:

$$t = \frac{b_1 - b_2}{S_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

$$H: \; b_1 = b_2$$

where

$1 = 1950$

$2 = 1959$

b = regression coefficient

S_p = pooled standard deviation

n = sample size

2/ The test statistic that was used here was:

$$F = \left(\frac{m_2}{m_1}\right) \frac{\int_w - \int_r}{\int_r}$$

$$H: \; \alpha_1 = \alpha_2, \; \beta_1 = \beta_2, \; \dots, \; \sigma_1 = \sigma_2$$

where

$1 = 1950$

$2 = 1959$

$\int_w = NS_p^{\,2} \, (1 - R_p^{\,2})$

$\int_r = n_1 S_1^{\,2} \, (1 - R_1^{\,2}) + n_2 S_2^{\,2} \, (1 - R_2^{\,2})$

p = pooled relations

S^2 = variance

R^2 = correlation coefficient squared

m_1 = degrees of freedom of numerator

m_2 = degrees of freedom of denominator

A comparison of the driving-time relationships found in the two time periods analyzed is presented in Table 2. These data indicate that, on the average, routes operated over longer distances (46.71 miles in 1959, compared to 38.68 in 1950) but served fewer customers (14.25, compared to 23.64). The statistical tests led to a rejection of the hypothesis that the relationships were equal in both time periods.[1/]

These results indicated that conditions affecting driving-time requirements in the Los Angeles area had changed significantly between the two time periods analyzed. There are many possible explanations for these changes, probably the most important being differences in traffic densities and the increased number of freeways. Automotive vehicle registration in Los Angeles County increased from 2.1 million in 1951 to 3.3 million in 1959, and, between 1953 and 1958, approximately 260 miles of new roadway were constructed in Los Angeles County.[2/] In addition, new state expressway mileage (which is not included in the above figure) increased substantially.

On the basis of the evidence indicated above, the relationships determined in the 1959 analyses were judged to better describe current conditions in this area. The new combined driving-time relationship is as follows:

$$T_1 = 41.38 + 1.85M + .588C \qquad (1)$$

T_1 represents driving time in minutes, M relates to driving distance in miles, and C refers to the number of customers served on the route. As a result of the change from the 1950 to the 1959 combined driving-time relationship, the fixed driving time per day increased by 6.9 minutes, while the average driving time required per mile decreased by .27 minutes, and the driving time associated with each customer decreased by .42 minutes.

Direct Delivery Time.--This part of the analysis includes time requirements for services performed at the customer's establishment by the route driver. Time observations for each set of services begin when the truck arrives at the

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1/ The 10 per cent level of significance was used to determine critical regions. All measurements except one inferred rejection. The value of "F" for the driving-time relationship from first stop to last stop did not fall in the rejection region.

2/ Los Angeles County Road Department, Annual Report, 1957-58 (Los Angeles County, California, April 30, 1959), 30p.

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TABLE 2

Effect on Distance Traveled and Number of Customer Stops on Time Spent in Driving Wholesale Milk Delivery Routes, Los Angeles, 1950 and 1959

Area covered	Total distance a/		Fixed time per day		Time per mile		Time per customer		Corrected correlation coefficient	
	1959	1950	1959	1950	1959	1950	1959	1950	1959	1950
	per cent		minutes							
Plant to first stop	25.5	18.3	8.47	5.41	1.57	2.08			.89	.884
First stop to last stop	46.3	58.1	18.89	20.32	2.38	2.14	.588	1.01	.94	.901
Last stop to plant	28.2	23.6	14.02	8.74	1.25	2.07			.74	.873
Combined	100.0	100.0	41.38	34.48	1.85 b/	2.12 b/	.588	1.01		

a/ Total distance for 1950 was 38.68 miles; for 1959, 46.71 miles.

b/ Obtained by weighting the average mileage by the proportion of the mileage traveled in each phase of the total route coverage.

buyer's premises and end when the driver re-enters the truck cab ready to continue on his route. While the number and type of services performed vary, the following functions are "typically" provided:

1. Secure order.
2. Put up order.
3. Deliver order.
4. Have customer check delivery.
5. Service dispensing box.
6. Obtain cash or signature.
7. Complete delivery; that is, pick up empty cartons, return to truck, etc.

At some establishments, the driver also:

8. Services the storage box.
9. Services the dispensing box from the storage box.

In the 1959 study, each delivery was classified according to the number of services performed. Since the predominant combination of delivery services included the functions (1) through (7), inclusive, a delivery which consisted of this combination was classified as a "normal" delivery and was denoted by the symbol "N." Where additional services were also performed--such as servicing the storage box (8) and servicing the dispensing box from the storage box (9)--the deliveries were noted as "N + 8 + 9." In some cases--notably those deliveries made by specialized firms--substantially fewer services than "normal" were provided. The operation of one such firm, for example, merely required that the driver deliver an order which had previously been arranged and loaded on the truck, have the store manager check the delivery, and perform the services associated with completing the delivery. A delivery service of this type was noted as "N - 1 - 2 - 5 - 6."

Each of the 424 deliveries observed in 1959 was further classified into one of the following groups:

1. Groceries and markets with normal service (122 stops).
2. Restaurants, fountains, and liquor stores with normal service (148 stops).
3. Groceries and markets with normal + 8 + 9 service (20 stops).
4. Restaurants, etc., with normal + 8 + 9 service (21 stops).
5. Groceries, restaurants, etc., with normal - 5 service (48 stops).
6. Institutions (29 stops).

7. All types of customer groups where less than six of the seven phases of normal service were performed (17 stops).

In addition, deliveries made by specialized firms--all to supermarkets--were classified in the following manner:

8. Deliveries where the driver had advance notice of the quantity to be delivered and where he was not required to service a dispensing box (N - 1 - 5).
9. Deliveries where, in addition to the above, the products to be delivered had been previously arranged (N - 1 - 2 - 5).
10. Deliveries where the service of obtaining either cash or signature was not required (N - 1 - 2 - 5 - 6).

Included in this latter group were eight stops of the first type, five of the second type, and six stops where the most limited type of service combination was performed. Statistics concerning the volume delivered and number of customers served, by type of customer and by type of service, are shown in Table 3.

The large disparity between the average delivery size of the specialized and independent firms is apparent from this table. Based on the sample obtained in the 1959 time studies, the average volume per stop served by the specialized firms was ten times larger than the average volume delivered by the independent firms. The 19 deliveries observed for the specialized firms accounted for 4.5 per cent of the total deliveries observed, but these deliveries accounted for more than 30 per cent of the total volume included in the study. It should be noted that the measure of volume is the "labor unit." This is a system of weights developed by the Bureau of Milk Stabilization by which the various products and container sizes handled on milk routes can be aggregated. In theory, each labor unit is equivalent--in terms of its labor requirements--to a quart of milk.

In the 1959 sample, about 25 per cent of the deliveries to groceries and markets (48 of 190) involved a set of services less than the full normal complement--(1) through (7). In this 25 per cent of the deliveries to markets, no services were performed on the dispensary box (service type N - 5). In the earlier study, the more limited type of delivery service--excluding service to display case--was the predominant case. In 1950, the dispensary boxes were serviced in less than 20 per cent of the deliveries made to groceries and markets. Since the amount of service provided can reasonably be expected to influence time requirements, this observation provides a basis for a change in the underlying time-volume relationship.

TABLE 3

Volume Delivered and Number of Customers by Type of Customer and Type of Service, Los Angeles Area, 1959

Type of customer and type of service	Volume delivered	Number of customers	Volume delivered	Number of stops
	labor units		per cent of total	
Independent firms				
Groceries and markets with normal service (N)[a]	45,009	122	32.78	28.77
Restaurants, fountains, and liquor stores with normal service	14,472	148	10.54	34.91
Groceries and markets with N + 8 + 9 service	6,776	20	4.93	4.72
Restaurants, etc., with N + 8 + 9 service	2,964	21	2.16	4.95
Groceries, restaurants, etc., with N - 5 service	17,169	48	12.50	11.32
Institutions	3,101	29	2.26	6.84
All types with less than six of the seven phases of normal service	3,619	17	2.64	4.01
Specialized firms				
N - 1 - 5	9,709	8	7.08	1.88
N - 1 - 2 - 5	13,314	5	9.69	1.18
N - 1 - 2 - 5 - 6	21,174	6	15.42	1.42
Total	137,307	424	100.00	100.00

a/ Normal service includes delivery functions (1) secure order; (2) put up order; (3) deliver order; (4) have customer check delivery; (5) service dispensing box; (6) obtain cash or signature; (7) complete delivery; (8) service the storage box; and (9) service the dispensing box from the storage box.

Table 4 shows the cumulative frequency distributions of number of customers and total volume, by volume groups, for delivery to groceries and markets for both the 1950 and 1959 samples. In the 1950 study, half of the customers received less than 50 labor units of milk products for delivery, but these customers accounted for only 13 per cent of the total volume. At the other extreme, less than 3 per cent of the customers received 500 or more labor units, and these large-volume customers accounted for more than 30 per cent of total volume. The frequency distribution for the 1959 sample indicates a much larger average delivery size.1/ In 1959, roughly one-half of the number of customers received less than 200 labor units per delivery, while this accounted for about 12 per cent of the total volume delivered. Almost 25 per cent of the customers received more than 500 labor units in 1959, and these customers accounted for nearly 65 per cent of the total milk and dairy products delivered.

Intensive analyses of the 1950 data revealed that the functions relating time requirements and volume per delivery were not linear and that the relatively simple curve types (such as second-degree parabolas) that could be fitted mathematically were inappropriate for the entire range of the data. Furthermore, tests were made to determine whether the dispersions of the data being analyzed were homoscedastic. This investigation showed that the variances of the time requirements are not equal but are an increasing function of the volume of milk delivered. Therefore, use of the more orthodox forms of mathematical regression and correlation techniques did not seem appropriate for this problem.2/

Group means were calculated for time requirements by volume groups for the two most important customer groupings--groceries and markets with normal service and restaurants, fountains, and liquor stores with normal service. These are

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1/ This may be due, in part, to the trend toward increased milk sales per store associated with the increased size of supermarkets in this area and, in part, to the increased size per delivery resulting from decreases in the number of deliveries due to incentives provided by the volume-pricing procedures. In all probability, however, this difference in average volume is a reflection of the difference in the samples obtained in the two studies. It should be recalled that reference was made earlier to the fact that in neither case were the samples representative. In both instances, efforts were made to obtain as large a number of large-volume stops as possible. It is entirely possible, therefore, that these efforts to obtain large-volume observations were more "successful" in 1959 than in 1950.

2/ For a more complete discussion of the analytical techniques used, see Clarke, op. cit.

[illegible]

[illegible]

[illegible]

TABLE 4

Cumulative Frequency Distributions of Number of Customers and Volume Delivered, Groceries and Markets Los Angeles, 1950[a] and 1959

Volume per stop	Cumulative percentage of			
	Number of customers		Volume delivered	
	1950	1959	1950	1959
labor units				
0- 14	11.3	.8	1.1	.01
15- 24	25.0	5.7	3.7	.3
25- 49	50.6	18.8	12.8	1.7
50- 74	66.7	26.2	22.3	2.9
75- 99	76.7	35.2	30.7	5.1
100-124	81.9	39.3	36.2	6.4
125-149	85.5	43.4	41.0	7.9
150-174	88.3	46.7	45.4	9.4
175-199	89.8	47.5	48.1	9.8
200-224	91.2	50.8	50.9	11.7
225-249	92.4	54.1	53.5	13.8
250-274	93.0	55.7	55.1	15.0
275-299	93.9	58.2	57.5	17.0
300-349	94.9	61.5	60.6	19.8
350-399	95.8	67.2	64.1	25.6
400-449	96.5	72.1	66.8	31.2
450-499	97.1	75.4	69.3	35.3
500 and over	100.0	100.0	100.0	100.0

a/ For 1950 stops, the type of service is N - 5, while for the 1959 stops, it is N, where N - 5 does not include dispensary box service. N is normal service, which includes delivery functions (1) secure order; (2) put up order; (3) deliver order; (4) have customer check delivery; (5) service dispensing box; (6) obtain cash or signature; and (7) complete delivery, that is, pick up empty cartons, return to truck, etc.

[illegible]

[illegible]

[illegible]

plotted on Figure 2, where the small x's refer to averages of the grocery group, and the small o's refer to the means of the restaurant group. The time-volume relationship determined in the 1950 study is also plotted on this figure. This relationship is the lowest curve and is labeled 1950. With but few exceptions, all of the observed group means consistently fall above the 1950 time-volume relationship, indicative of differing conditions between the delivery operations observed in 1959 and those studied in 1950. This differential could result from the previously mentioned change in delivery service components observed between the two time periods studied or from differences in basic techniques of delivery, such as the use of different handling facilities.

Since the data from the 1950 analysis were sufficiently detailed, a functional relationship could be determined between time and dispensary box service. This relationship was then added to the 1950 time-volume function to provide an estimate of the adequacy of this earlier relationship, when adjusted to be consistent with current delivery services, in representing the 1959 results.

For purposes of comparison, the following set of equations can be used to represent the 1950 time-volume relationship based on delivery services not including dispensary case service:1/

For volume per stop of less than 377 labor units:

$$T_2 = 3.33 + .08556V_s - .0000806V_s^2 \qquad (2)$$

For volume per stop of 377 labor units or more:

$$T_2 = 14.76 + .024875V_s \qquad (3)$$

When this relationship is adjusted to include the dispensary box service, still based on the 1950 study, these equations become:

For volume per stop of less than 377 labor units:

$$T_2 = 3.52 + 0.08869V_s - .0000806V_s^2 \qquad (4)$$

For volume per stop of 377 labor units or more:

$$T_2 = 14.95 + 0.0280V_s \qquad (5)$$

In both sets of equations, T_2 represents direct delivery time per stop in minutes, while V_s refers to the volume (measured in labor units) of milk and other dairy products delivered. This adjusted time-volume relationship is plotted on Figure 2 and labeled 1950a.

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1/ It should be noted that this regression was fitted graphically rather than by the use of mathematical techniques. The curve which was drawn to these data, however, can be described in mathematical terms.

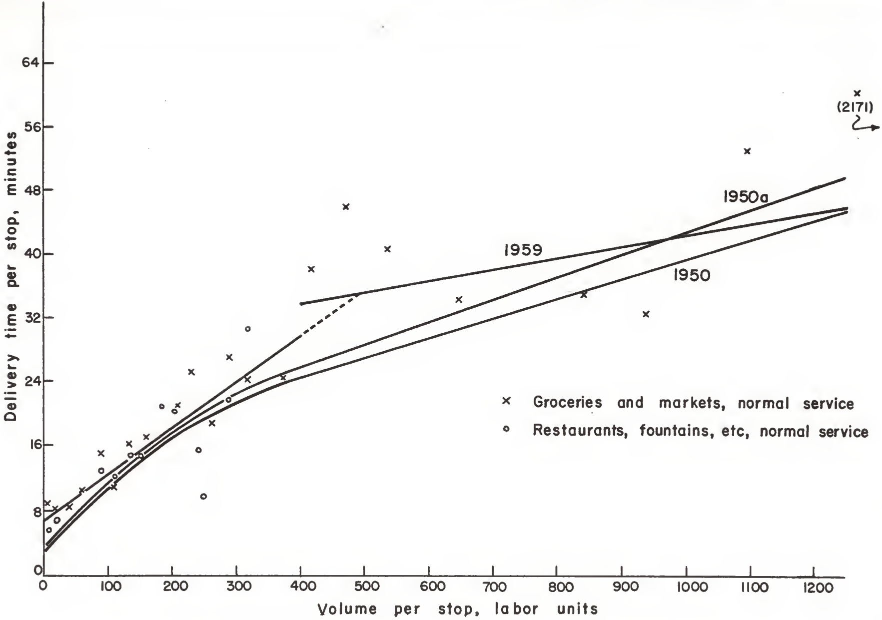

Figure 2. Effect of Volume Per Stop on Direct Delivery Time, Los Angeles, 1959

Upon observation, it appears that the adjusted 1950 relationship fails to provide a "good fit" to the 1959 data. In particular, it tends to underestimate time requirements for the smaller volume deliveries.

If the purpose of this analysis were solely to determine a set of equations that would most closely "fit" the 1959 data, its objective might best be achieved by the use of two line segments such as those labeled 1959 in Figure 2. Based on observation, the group means plotted in Figure 2 appeared to divide themselves into two separate types of relationships--one descriptive of the data for deliveries of less than 400 labor units and one relating to deliveries of 400 units or more. For this reason, the data were segregated into these two volume groups. Linear regression equations--using least-squares techniques--were then mathematically determined from the observations of group means of deliveries less than 400 labor units and from the mean observations of 400 units or more. These regression equations are plotted on Figure 2 and determine the two line segments referred to previously and which are labeled 1959. Since these two regression equations (when 400 units is the upper and lower limit, respectively) do not cross, a linear extension to the equation representing the smaller volume group was made up to the point where the lines intersect. From this procedure, the following expression of the 1959 time-volume relation was determined:

For volume per stop of less than 494 labor units:

$$T_2 = 6.770649 + 0.057884V_s \qquad (6)$$

For volume per stop of 494 labor units or more:

$$T_2 = 28.019764 + 0.014835V_s \qquad (7)$$

In view of the fact that the 1950 relationship was fitted graphically rather than mathematically, it was not feasible to make statistical tests of hypotheses regarding the probability that the observations contained in the 1950 and in the 1959 studies were, in fact, drawn from the same population. The following conditions with respect to the nature of the data were noted:

1. The number of delivery-time observations was much greater in the 1950 study--2,689, compared with 424 in the 1959 analysis.
2. The variation in observed time requirements was quite large, and this variance increased greatly with increases in the volume delivered.
3. On logical grounds, it would be expected that delivery-time requirements would increase continuously with increases in average delivery sizes.

[illegible]

On a priori grounds, therefore, the decision was made to use the 1950 time-volume relationship, adjusted to include the additional services. The primary basis for this decision was that the much larger 1950 sample provided greater "stability" between the group means, thus tending to average out the effect of random variations in time requirements resulting from factors other than the volume of products delivered. These random variations, which are responsible for the high variance among observations, could explain most of the differences between the 1950 and 1959 studies. In fact, if delivery techniques and relative effort expended by the deliveryman remained the same during the two periods analyzed, it can be argued that these random variations would explain such differences. On observation, there were no logical bases to indicate that either techniques or labor productivity has changed; therefore, the use of the adjusted 1950 relationship is equivalent to accepting the hypothesis that the two samples were drawn from the same population. The relationship used to describe direct delivery-time requirements in the remainder of this report, therefore, are those expressed in equations (4) and (5).

Miscellaneous Time.--Several other operations are performed by wholesale milk deliverymen in addition to the direct serving of the customers and the driving components previously discussed. These duties include checking the load against daily requirements prior to leaving the plant, arranging the load and attending to personal needs while on the route, and checking in and making settlement with the plant cashier on return to the plant.

When the 1950 analyses were made, time data on these operations were analyzed to determine whether relationships existed between volume per route and/or the number of customers served and the time spent in these operations. No meaningful results were obtained from these analyses. Since there was no significant influence of route volume and number of customers on the amount of time spent in these miscellaneous operations, the averages determined from the sample routes have been used. For the 111 routes included in the 1950 analyses, the mean time spent on all operations other than driving and direct delivery, but exclusive of lunch time, amounted to 75.4 minutes, of which 71.2 minutes were spent in arranging loads and at the plant and 4.2 minutes were classified as personal time. In 1959, the mean time for these operations was 88.3 minutes. A breakdown into time components is given in Table 5. The time requirement for arranging the load and at-plant activities is quite comparable in the two studies--73.4 minutes in 1959, compared with 71.2 minutes in 1950. Personal time averaged slightly higher in

[illegible]

[illegible]

[illegible]

TABLE 5

Time Components of the Miscellaneous Time Category
Wholesale Routes, Los Angeles, 1959

Time component	Average time per route
	minutes
Time at plant before delivery	21.5
Time at plant after delivery	33.9
Inventory truck load	13.2
Arrange truck load	4.8
Wait	8.5
Personal time	6.4
Total	88.3

the later study--6.4, against 4.2 minutes in the 1950 analysis. The major difference between the miscellaneous time requirements in the two studies, therefore, stems from the fact that in the later period an average of 8.5 minutes of waiting time that was not assignable to any particular customer delivery was involved. For the purpose of the reanalysis, the mean time of 88.3 minutes determined from the 1959 sample was used. Therefore:

$$T_3 = 88.3 \tag{8}$$

where T_3 represents miscellaneous time, in minutes, per route day.

Total Time

For analytical purposes, total route time was divided into three component elements: driving time (T_1), direct delivery time (T_2), and time spent in miscellaneous operations (T_3). Each component was analyzed, and the relationships, if any, between the time requirements for these elements and the major time-affecting variables were determined. These relationships, expressed as estimating equations, are summarized in Table 6.

In the table, these individual expressions of time requirements for the various components can be combined to obtain an estimating equation for total time requirements as functions of the number of customers (C), the volume per delivery (V_s), and the number of miles covered by the route (M). Two equations are required--the first applicable for stops of less than 377 labor units and the second appropriate in the larger volume delivery:

For volume per stop of less than 377 labor units:

$$T = 129.68 + 4.108C + \sum_{i=1}^{C} (0.08869V_{si} - .0000806V_{si}^2) + 1.85M \tag{9}$$

For volume per stop of 377 labor units or more:

$$T = 129.68 + 15.538C + \sum_{i=1}^{C} (0.0280V_{si}) + 1.85M \tag{10}$$

The V_{si} represents the volume delivered at any given stop (i), and the direct delivery time is thus expressed as the aggregate of all stops on the route.

With only a minor loss in accuracy, the variables contained in parentheses in the above equations--V_{si} and V_{si}^2--can be treated as average volumes per stop ($\bar{V}_s$). When this is done, the need for aggregating direct delivery time over all stops is eliminated, and this component can be estimated by multiplying by C, the number of customers served. Because of the fact that $\bar{V}_sC$ equals V_r--

TABLE 6

Summary of Time Requirements for Wholesale Milk Delivery Routes, Los Angeles, 1959

Elements	Fixed minutes per day	Minutes per customer: Fixed	Minutes per customer: Variable	Minutes per mile
Driving	41.38	.588		1.85
Direct delivery				
Under 377 labor units		3.52	$0.08869V_s - .0000806V_s^2$	
Over 377 labor units		14.95	$0.0280V_s$	
Miscellaneous	88.3			
Totals:				
Under 377 labor units	129.68	4.108	$0.08869V_s - .0000806V_s^2$	1.85
Over 377 labor units	129.68	15.538	$0.0280V_s$	1.85

the route volume--these two equations may be expressed in the alternative forms given below in order to introduce the influence of route volume:

For routes averaging less than 377 labor units per stop:

$$T = 129.68 + 4.108C + .08869V_r - .0000806V_r\bar{V}_s + 1.85M \quad (11)$$

For routes averaging 377 or more labor units per stop:

$$T = 129.68 + 15.538C + .0280V_r + 1.85M \quad (12)$$

Truck Operating Expenses

Separate analyses of truck costs, based on original records, were not made in either the 1950 or the 1959 studies, since summary data of such costs were available in sufficient detail to provide the necessary information on the nature of these costs. The Bureau of Milk Stabilization regularly makes intensive studies of processing and distribution costs. Included in these analyses is a breakdown of the elements of truck expense. These summaries contain both direct operating costs, such as gasoline and oil, tires, repairs, depreciation, taxes and licenses, etc., and indirect operating expenses, such as supplies, laundry, and general overhead allowances for the operation and maintenance of the garage and storage facilities.

The total expenses in these categories applicable to wholesale milk delivery trucks, the number of wholesale milk route days operated, and the total volume per day (in labor units) of milk products distributed were made available by the Bureau. From this information, it is possible to calculate the average truck operating costs per route day.

Analyses of these averages made during the 1950 study indicate that daily truck costs increase as the average size of load increases. The available accounting records do not reveal the reasons for this increase in cost per day, but, logically, such cost increases would result from such things as the fact that larger trucks are required to handle the larger loads. The larger trucks involve heavier depreciation charges and require greater rates of gasoline, oil, and tire consumption. Furthermore, if two trips are made with a smaller truck in order to handle the additional volume, the total route mileage would increase and, again, truck costs per route day would rise. A straight-line relationship (based on 1950 cost levels) was determined. The equation describing this relationship is:

$$TC = \$4.59 + 0.002378V_r \quad (13)$$

where TC represents truck operating expense per route day and V_r represents the total volume handled per route expressed in labor units.

Similar cost information was made available by the Bureau of Milk Stabilization for truck operating expenses during the most recent period for which studies had been made in the Los Angeles area (1958). These data compared quite closely to the 1950 regression equation, so the truck cost estimating equation indicated above (13) has been retained in the present reanalysis.

Total Delivery Costs

Labor requirements and truck costs have been developed now in terms of the interrelated variables, including the number of customers served (C), the total volume handled on the milk route (V_r), the average volume per stop ($\bar{V}_s$), and route mileage (M). By specifying route distance as a constant term, the expression for time requirements can be further simplified.1/ The constant term used in this analysis is the average mileage traveled (46.71 miles) by the routes covered in the 1959 study.

As mentioned in a previous section, delivery labor costs per day in the Los Angeles market are specified by union agreement at $29.73 for an average work day which consists of 494 minutes. This constant term of 494 minutes can, therefore, be substituted in the left-hand side of the equation representing time requirements, thus yielding an expression of route volumes (V_r) in terms of the single variable, delivery volume (V_s). These expressions are:

For routes averaging less than 377 labor units per stop:

$$V_r = \frac{277.91}{4.108/V_s + .08869 - .0000806V_s} \qquad (14)$$

For routes averaging 377 or more labor units per stop:

$$V_r = \frac{277.91}{15.53/V_s + .028} \qquad (15)$$

The above formulas for determining route volume have been applied to varying delivery volume, and the results are shown in the second column of Table 7.

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1/ For the purpose of the present analysis, which is specifically to determine the relationships between costs and volume per stop, the effect of specifying mileage as a constant is tantamount to saying that route distances are unrelated to the variables analyzed--route volumes, number of customers served, and average delivery volumes. Summary analyses of the data obtained in the various studies made throughout California markets failed to reveal any direct relationship between miles traveled and these variables, and so this assumption is considered feasible.

Similar [illegible] information [illegible] made available [illegible] this investiga-
tion [illegible] during the [illegible] period [illegible]
[illegible] (1958). [illegible]
[illegible]
[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

$$[illegible] \qquad (13)$$

[illegible]

$$[illegible] \qquad (14)$$

[illegible]

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[illegible]

TABLE 7

Volume-Per-Customer Relationships with Route Volumes and Delivery Cost Components, Using 1959 Driving-Time Coefficients and 1950 Delivery-Time Coefficients Adjusted to Include Icebox Service
Los Angeles, 1959

Volume per customer	Total route volume[a]	Labor costs per route	Truck costs per route[b]	Total costs per route[c]	Total costs per labor unit[d]
labor units		dollars			
10	557	29.73	5.92	35.65	.0640
50	1,666	29.73	8.55	38.28	.0230
100	2,283	29.73	10.02	39.75	.0174
150	2,672	29.73	10.95	40.68	.0152
200	2,985	29.73	11.69	41.42	.0139
250	3,271	29.73	12.37	42.10	.0129
300	3,554	29.73	13.04	42.77	.0120
400	4,159	29.73	14.48	44.21	.0106
500	4,706	29.73	15.78	45.51	.0097
1,000	6,384	29.73	19.77	49.50	.0078
1,500	7,246	29.73	21.82	51.55	.0071
2,000	7,770	29.73	23.07	52.80	.0068
3,000	8,377	29.73	24.51	54.24	.0065
4,000	8,717	29.73	25.32	55.05	.0063
5,000	8,934	29.73	25.84	55.57	.0062
6,000	9,086	29.73	26.20	55.93	.0062
7,000	9,196	29.73	26.46	56.19	.0061
8,000	9,282	29.73	26.66	56.39	.0061

a/ Computation of total route volume:

For routes averaging less than 377 labor units per stop:

$$V_r = \frac{277.91}{4.108/V_s + .08869 - .0000806V_s}$$

For routes averaging 377 or more labor units per stop:

$$V_r = \frac{277.91}{15.53/V_s + .028}$$

where V_r is route volume and V_s is volume per customer.

b/ Computation of truck cost:

$$TC = \$4.59 + 0.002378V_r$$

where TC represents truck operating expense per route day and V_r represents the total volume handled per route expressed in labor units.

c/ Labor cost plus truck cost.

d/ Total cost divided by total route volume.

As indicated, truck expenses per route day can be expressed as a function of total route volumes; therefore, estimates of truck costs per day are obtained in the fourth column of the table by applying the appropriate route volume (column 2) to the previously described truck cost estimating equation.

Total delivery costs per route day, the sum of labor costs plus truck costs, appear in the fifth column. When total delivery costs are divided by column 2, total delivery cost per labor unit (column 6) is obtained, which provides the final results of the delivery cost analysis.

A comparison of the differential route volumes resulting from the application of the revised time requirements is presented in Table 8. Column 2 lists route volumes associated with alternative average deliveries per stop when the 1950 relationship was applied, while column 3 is the result of the use of 1959 statistics. This shows that, while route volumes increased rapidly with large volume stops, the rate of increase is smaller under current delivery conditions than could be expected in 1950. This undoubtedly was the result of the adoption of the added services to the dispensary cases which increased the amount of delivery time at each customer stop, especially since the amount of time spent performing such services increased (though less than proportionately) as volume per stop increased. The fact that route volumes associated with small deliveries under 1959 conditions were larger than were achieved when the 1950 relationship was applied primarily stems from the lowered driving-time requirements which increased the time available to the driver to make deliveries. It should be noted that identical route mileages were assumed in the calculations for this table.

The combined effect of changes in the time requirements and in labor costs that occurred between 1951 and 1959 is also shown in this table. Columns 4 and 5 present the total delivery costs per route day, based on cost rates and time requirements appropriate for 1951 and 1959, respectively. These are further illustrated in terms of costs per unit in columns 6 and 7. The final column of this table presents an estimate of 1959 unit delivery costs, assuming the 1950 delivery time-volume relationships were still valid.

Application of Cost Findings to Problems of Pricing

The differential costs associated with varying sizes of wholesale milk deliveries have just been described. These figures emphasize the fact that unit costs decrease rapidly with increases in volume delivered. Thus, Table 7 shows

TABLE 8

Comparison of Route-Volume, Volume-Per-Stop Relationships and Delivery Costs, Los Angeles, 1950 and 1959

Volume per stop	Route volumes		Delivery costs per route day		Delivery costs per labor unit		
	1950a/	1959b/	1951c/	1959d/	1951	1959	1959Ae/
	labor units		dollars				
10	525	557	24.57	35.65	.0468	.0640	.0678
50	1,617	1,666	27.20	38.28	.0168	.0230	.0236
100	2,251	2,283	28.67	39.75	.0127	.0174	.0176
150	2,658	2,673	29.60	40.68	.0111	.0152	.0153
200	2,987	2,985	30.34	41.42	.0102	.0139	.0139
250	3,289	3,271	31.02	42.10	.0094	.0129	.0128
300	3,589	3,554	31.69	42.77	.0088	.0120	.0119
400	4,238	4,159	33.13	44.21	.0078	.0106	.0105
500	4,830	4,706	34.43	45.51	.0071	.0097	.0095
1,000	6,702	6,384	38.42	49.50	.0057	.0078	.0075
1,500	7,696	7,246	40.47	51.55	.0053	.0071	.0068
2,000	8,313	7,770	41.72	52.80	.0050	.0068	.0065
3,000	9,037	8,377	43.16	54.24	.0048	.0065	.0062
4,000	9,448	8,717	43.97	55.05	.0047	.0063	.0060
5,000	9,713	8,934	44.49	55.57	.0046	.0062	.0059
6,000	9,899	9,086	44.85	55.93	.0045	.0062	.0058
7,000	10,035	9,196	45.11	56.19	.0045	.0061	.0058
8,000	10,140	9,282	45.31	56.39	.0045	.0061	.0058

a/ Based on relationships between volume per stop and route volumes determined from 1950 studies.

b/ Based on relationships between volume per stop and route volumes determined from 1959 studies.

c/ Using 1951 labor rates of \$18.65 per route day and truck operating expense determined by the formula TC = \$4.59 + $0.002378V_r$ per route day, where TC represents truck operating expense per route day and V_r represents the total volume handled per route expressed in labor units.

d/ Using 1959 labor rates of \$29.73 per route day and truck operating expense determined by the formula TC = \$4.59 + $0.002378V_r$ per route day.

e/ Using 1959 labor rates but 1950 delivery time relationships.

that delivery costs in the Los Angeles area dropped from nearly 6 1/2 cents per labor unit with a volume of 10 labor units per customer delivery to 1 3/4 cents per labor unit with a volume of 100 units and continued to decline at a decreasing rate to approximately 3/4 cent per unit with a volume averaging 1,000 units per customer.

Before these differential costs associated with varying delivery sizes can be applied to a pricing schedule, it is necessary to estimate costs and allowances other than delivery expenses which are associated with the price of a given amount of milk. These nondelivery costs include the cost of raw products (the farm price for the milk, plus transportation and handling charges involved in moving the milk from the farm to the city plant); processing (city plant) costs, including receiving, pasteurizing, and bottling expenses; and general overhead and administrative costs plus allowable profits.

The amount of nondelivery costs was estimated by taking the average (discounted) price of a quart of milk delivered at wholesale in the Los Angeles market less the cost of delivery. At the time of the 1959 study, the base price for milk delivered to wholesale customers was 20.5 cents per quart.[1/] This price, however, was subject to a discount of 8 per cent on any amount delivered with a value in excess of $10. Since it was determined that the average discount in the market amounted to 1.1 cents, the figure of 19.4 cents per quart was used to represent the average price. Delivery costs of this average volume of delivery (125 labor units) amounted to 1.6 cents per quart. Therefore, by deducting delivery costs from the average price received, an estimate of 17.8 cents was obtained and used herein to represent nondelivery cost levels. This was approximately 2½ cents larger than the nondelivery costs obtained by similar procedures for the 1950 analysis (15.4 cents).

The results of adding the 1959 nondelivery costs to the different delivery costs associated with varying delivery sizes (Table 7, column 6) are shown graphically on Figure 3. This represents the unit cost-volume function representative of Los Angeles market conditions in 1959. As can be seen from this

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1/ The Stabilization and Marketing Plan for the Los Angeles marketing area includes a "seasonal adjustment" in the producer price--or the raw product cost of milk. These prices are normally the equivalent of 1/2 cent per quart lower during the months of April through August than for the period September through March. In the discussion to follow, prices and costs are based on levels consistent with the latter period with the higher prices.

and delivery costs to the [illegible] have dropped from nearly [illegible] mills per [illegible] with a volume of [illegible] without delivery [illegible] [illegible] with a volume of [illegible] mills and continues to decline [illegible] to approximately [illegible] [illegible] averaging [illegible] mills per [illegible].

[illegible] associated with [illegible] delivery [illegible] a pricing [illegible], it is necessary [illegible] costs [illegible] delivery [illegible] associated with the price of a given [illegible]. [illegible] would include the cost of the [illegible] transportation and [illegible] to the [illegible] consisting [illegible] and [illegible] along [illegible].

The [illegible] was [illegible] by taking the average [illegible] value of a [illegible] delivered [illegible] to [illegible] [illegible] in the case of the [illegible] study, the [illegible] [illegible][1] This [illegible], however, was [illegible] of [illegible] per [illegible] [illegible] it was [illegible] the [illegible] in the [illegible] and [illegible] was used to represent the [illegible] [illegible] to [illegible] [illegible] per [illegible]. Therefore, [illegible] delivery [illegible] from the average [illegible] [illegible] was [illegible] [illegible] [illegible] for the [illegible] ([illegible]).

The results of [illegible] the [illegible] to the [illegible] delivery [illegible] delivery [illegible] (Table [illegible], column [illegible]) and shown [illegible] in Figure [illegible]. This represents the [illegible] [illegible] of the [illegible] in [illegible]. It can be seen from this

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[1] The [illegible] for the [illegible] [illegible] [illegible] the [illegible] [illegible] of [illegible] [illegible] the months of April through August [illegible] the [illegible] [illegible] [illegible] with the higher [illegible].

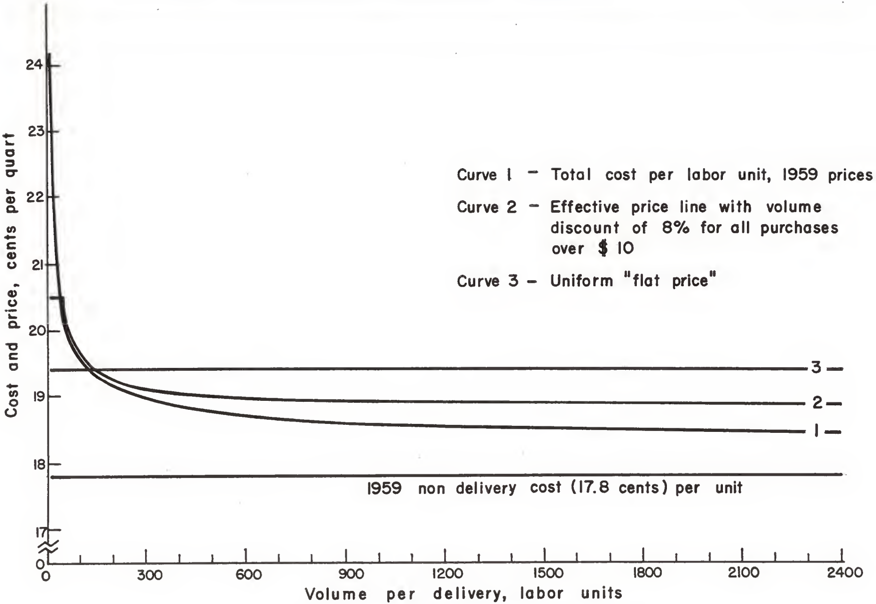

Figure 3. Comparison of Unit Costs for Various Quantities Delivered Per Stop with Alternative Pricing Schedules, Wholesale Sales, Los Angeles, 1959

function, the total costs of delivered milk to wholesale customers range from a little more than 34 cents per quart for deliveries of 10 labor units or less, to approximately 18.6 cents per quart when volumes of 1,000 labor units are delivered, to slightly below 18.4 cents per quart when delivery sizes exceed 5,000 units per stop.

This figure also shows the effective price resulting from the discount system in effect in the Los Angeles area in the first part of 1959. This schedule involved a base price of 20.5 cents per quart with a discount of 8 per cent on any amount delivered in excess of a value of $10. Under this system and at these price levels, the equivalent of the first 48 quarts would not be subject to discount. Therefore, the effective price for milk delivered up to this quantity is the base price of 20.5 cents, as indicated by the horizontal segment of the curve of the diagram. Milk delivered in excess of the first $10 of value takes on the discount rate of 8 per cent, and the effective price line falls off rapidly in the range between 50 and 300 units and then levels off. This leveling off occurs as the effective price line asymptotically approaches the figure of 18.86 cents, which is the 20.5-cent price discounted at the full 8 per cent rate.

Comments on the Effectiveness of Existing Pricing Schedules in Reflecting Differential Costs

The second stated objective of this report is to evaluate the effectiveness of the present volume-pricing system, established by the Bureau of Milk Stabilization, in reflecting differential delivery costs. This can be done most effectively by further reference to Figure 3.

For present purposes, it is assumed that the "effectiveness" of any given price schedule is measured by the extent and degree to which it corresponds to the costs as shown in the figure. For comparative purposes, a horizontal line has been drawn on the figure corresponding to a 19.4-cent-per-quart uniform price.[1] This flat price--which was the system used in California prior to 1956--is completely unrealistic as a representation of distribution costs. In the range of volumes below 70 units per customer, actual costs exceed the fixed price, while, above this volume, costs are below the price.

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1/ This represents the average discounted price in the market under the present schedule. (See page 31.)

In relative terms, the 1959 pricing system provides a much better representation of costs, particularly in the approximate range covered by 50 to 200 labor units per delivery. Since this system involves a flat price (the base price of 20.5 cents) for deliveries of 48 units or less, it is subject to the same criticism just mentioned for low-volume delivery ranges. Specifically, it understates costs--and the amount by which the cost exceeds the price increases rapidly with the smaller delivery sizes.

The 1959 price system has a further disadvantage in that the effective prices exceed costs for the larger delivery volumes. The "gap" between the effective prices and the costs begins to become apparent at about 200 units per delivery and widens with the larger volumes per stop. The amount by which prices exceed costs approximates 1/2 cent a quart in the range of 2,000 units per delivery and above.

The initial limitation of the present pricing system--that the effective price falls below costs for low-volume stops--is a result of the policy position taken by the Bureau of Milk Stabilization. This position essentially involves two conditions that must be met. First, a single or uniform minimum price must be established at the retail, out-of-store level. Second, this minimum store price must provide some margin for all wholesale customers. In order to meet both of these conditions, the base price to be charged to all customers, regardless of volume, must be at a relatively low level.

The second limitation--that effective prices exceed costs for large-volume deliveries--can be met more simply. A closer relation between effective prices and costs can be achieved by changing the discount rate in such a way as to reduce the gap between prices and costs.

Alternative Price Schedules

The nature of the cost-volume relationship is such that no single price schedule can precisely reflect the differential costs through all volume ranges. This is because the total cost function is curvilinear up to volumes per stop of 377 labor units--a direct reflection of the delivery time-volume relationship--equation (4). This curvilinear relation can be closely approximated, however, by two line segments with the following coefficients:

$$TC = \$0.523 + \$0.190V_s \qquad (16)$$

$$TC = \$1.940 + \$0.184V_s \qquad (17)$$

These two lines intersect at a point corresponding to 236 labor units, so equation (16) reasonably represents the cost function for volumes per stop up

to 236 units, while equation (17) would be applicable to deliveries of 236 labor units or more. Two separate schedules--one for the smaller volume ranges (up to 236 labor units) and one for the larger delivery volumes (236 units or more) will provide results that will compare very closely to the costs shown in Figure 3.

Service-Charge Plans.--The above specification of the cost-volume relationship--equations (16) and (17)--points up two important facts: first, that total costs per stop increase--but at a less than proportional rate--with increases in volume delivered and, second, that there is a certain amount of "fixed" costs per stop which are unaffected by the quantity served. For these reasons, differential costs can best be reflected by the use of a service-charge procedure. Under this type of pricing system, the customer would pay the amount of the fixed costs in the form of a flat charge in addition to a base price per unit of milk delivered. As previously mentioned, two separate schedules are required, and, at 1959 cost rates, they are:

For deliveries of less than 236 units--a service charge of 52 cents per delivery plus a base price of 19 cents per quart of milk.

For deliveries of 236 labor units or more--a service charge of $1.94 per delivery with a base price of 18.4 cents per quart of milk.

A comparison of the effective prices under the above systems of service charges with the cost relation shown in Figure 3 is provided in Figure 4, where the effective prices are shown as large dots.

Discount Plans.--It has been noted earlier that two types of discount plans have been used for pricing milk sold to wholesale customers in California markets. The continuous type has been in effect in the Los Angeles area. Prior to September 1, 1959, this schedule involved a base price of 20.5 cents per quart with a discount of 8 per cent allowed on all amounts in excess of a value of $10. The effective prices under this plan and the extent to which it reflected costs were presented in Figure 3.

As was the case with service charges, two separate price schedules are required to closely reflect the nature of costs under a system of this type. Furthermore, certain "inflexibilities" are encountered in the use of this system which, in effect, reduce its accuracy. For example, discount rates stated in terms other than integers are difficult to handle; if the appropriate discount rate were 7.25 per cent, this would need to be rounded to 7 per cent to avoid the use of fractional percentages. Similarly, the portion excluded from discount is stated in dollar value terms, and these normally are rounded to even dollars.

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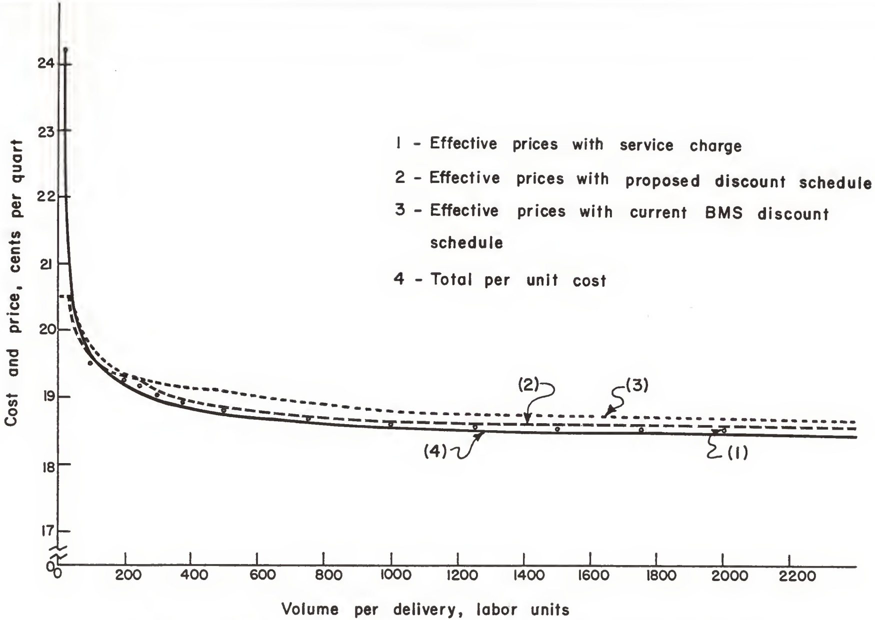

Figure 4. Comparison of Alternative Pricing Procedures in Reflecting Cost Differentials
Wholesale Routes, Los Angeles, 1959

Considering the above factors, the discount schedules--using a 20.5-cent base price--that would most closely reflect costs are:

For deliveries of less than 236 units--20.5 cents per quart, subject to a discount of 7 per cent on any amount over $7.

For deliveries of 236 labor units or more--20.5 cents per quart, subject to a discount of 10 per cent on any amount over $20.

A comparison of the effective prices, using the above pricing schedules, is also made in Figure 4, where these prices are indicated by the broken line curve.

Subsequent Changes in the Pricing System in Los Angeles

On September 1, 1959, a modification was made by the Bureau of Milk Stabilization in the wholesale volume-pricing program. This change was made primarily to reduce the disparity between the effective prices with a single discount rate and costs, particularly in the larger volume ranges. At the same time, the base price of milk was increased from 20.5 cents per quart to 20.6 cents.

The change in the schedule provided an additional 2 per cent discount on all amounts in excess of $100 per delivery. Thus, a customer receiving a delivery with a total value of $500 is allowed an 8 per cent discount on $490--the same rate that existed prior to the change--plus an added 2 per cent discount on $400.[1/] The effective prices under this new price schedule are shown by the dotted line curve on Figure 4. Since at current prices a delivery with a value of $100 corresponds to 485 labor units, the new price schedule reflects a decrease in effective prices in the range of approximately 500 units and larger and so has the effect of reducing the gap between prices and costs in this larger volume range.

The Impact of Volume Pricing on Wholesale Milk Delivery Operations in California Markets

Until 1956, resale milk prices to both wholesale and home-delivered customers were established on a uniform basis. During the fall of 1956 and the spring

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1/ With a 20.6-cent base price, a delivery valued at $500 would be consistent with a volume of 2,427 labor units. The discounted or "effective" price for this volume per stop under the pricing schedule being discussed is 18.66 cents per quart. This is equivalent to an average discount on the entire delivery of slightly more than 9.4 per cent.

of 1957, volume-pricing procedures were adopted in the major milk markets in the state.

The most important economic argument favoring adoption of volume-pricing programs centers around the opportunity for increased efficiency of milk marketing. Under the older, flat-price plan, individual grocery accounts found no incentive to deal entirely with a single dairy firm. Rather, as long as supplies were plentiful, the grocer was under some pressure to divide his trade among several distributors, thus taking advantage of any brand preference prevailing among his customers. Such procedure may, of course, be desirable, since it permits customers a choice among several brands. Perhaps consumers are also willing to pay the added costs in order to maintain this degree of choice. The point that was made, however, is that under a uniform pricing system the customer is not free to "elect" either a system which involves this choice at a higher cost or one in which choice is limited but costs are lower.

The present pricing system, under which the effective price of milk decreases as the volume per stop increases, provides an incentive to the grocer to reduce the number of split stops. As shown by the decreasing curve representing the effective price under the present system in Figure 4, the incentive to reduce the number of distributors serving a single grocery is greater for small stores than it is for large retail outlets. For example, assume that a grocery store has an average milk sale of 150 quarts per day (valued at net prices at approximately $31). If the management of this store decides to handle milk from three distributors and divides his account evenly between them, the cost of milk to the store will be the full 20.6 cents per quart undiscounted price. However, if the total requirements were purchased from a single distributor, the effective price, based on daily deliveries, would be 19.5 cents per quart--a saving of 1.1 cents per quart. A large supermarket with average daily milk sales of 3,000 quarts could decide to divide its patronage among three different distributors with a net added cost of less than 2/10 cent per quart.

An expected impact of volume pricing of milk at wholesale levels, therefore, is a decrease in the number of distributors serving each particular wholesale customer. This change, in turn, is expected to increase the average volume distributed per stop. As indicated in the previous analysis, the increases in the volume delivered per customer permit larger route volumes, consequently reducing delivery costs associated with the larger route sizes.

From cost analyses made by the Bureau of Milk Stabilization, data concerning the average volume served wholesale customers and the average route volumes

in various markets in the state were obtained. These figures were obtained for two time periods. For the earlier time period, data based on studies made prior to the adoption of volume-pricing programs were used. The data for the later period refer to the most recent figures available for these markets. A comparison of these figures for seven markets is provided in Table 9.

Two factors are of interest in this table. First, there is a definite indication that a relationship exists between volume per stop and load sizes; thus, route volumes in the Los Angeles market--where the average volume per delivery is largest--are the greatest. Conversely, route volumes are smallest in the San Francisco market, where the average quantities delivered per customer are lowest. Second, the average route volumes in each of the markets are greater in the period following the adoption of volume-pricing procedures than in the period in which uniform pricing programs were followed.

As mentioned above, changes in average route volumes are to be expected from the institution of a different type of pricing procedure. Many other market conditions, such as changes in the types and amounts of delivery services provided by the wholesale milk driver, may also influence load sizes. Additional services are now available in the Los Angeles market in the form of servicing dispensary cases--a service not "typically" performed in the early 1950's. (See page 15.) Changes in route volumes also may be expected to result from such factors as changes in the average size of retail outlets and changes in the number of supermarkets that become associated with captives. Since it was not possible in the present analysis to isolate the effect of such changing conditions mentioned above on route volumes, the data presented in Table 9 must be considered as "gross" changes rather than as the net effect of the change in the pricing system alone.

In spite of the above limitations of the data on comparative route sizes in the period prior to and following the institution of volume-pricing procedures, it is of interest to indicate the effect of increases in average load sizes on unit delivery costs. Table 10 presents the total delivery cost per route day, as well as the delivery cost per labor unit consistent with the average route volumes determined in the seven markets in the two time periods, when cost rates are held constant at levels appropriate for the Los Angeles market during 1959.

As indicated by this table, delivery costs per unit in the Los Angeles market are 2/10 cent per quart less for current route volumes than would have

TABLE 9

Average Delivery Volumes Per Customer and Route Volumes, Before and After the Adoption of Volume-Pricing Programs California Markets

Market	Prior to volume-pricing programs		Following volume-pricing programs	
	Volume per stop	Route volumes	Volume per stop	Route volumes
	labor units			
Los Angeles	81	2,377	125	2,786
San Francisco	37	1,518	53	1,844
Alameda-Contra Costa	44	1,693	70	2,125
Sacramento	60	2,248	104	2,399
Fresno	40	1,738	75	1,976
San Joaquin	53	1,580	79	1,875
San Bernardino-Riverside	91	2,266	92	2,357

TABLE 10

Wholesale Milk Delivery Costs Per Labor Unit, Based on Route Volumes Before and After Volume-Pricing Programs, 1959 Wage and Truck Cost Rates California Markets

Market	Route volumes prior to volume-pricing programs		Route volumes following volume-pricing programs	
	Total delivery costs per route[a]	Delivery costs per labor unit	Total delivery costs per route[a]	Delivery costs per labor unit
	dollars			
Los Angeles	39.97	.0168	40.94	.0147
San Francisco	37.92	.0250	38.70	.0210
Alameda-Contra Costa	38.35	.0227	39.37	.0185
Sacramento	39.67	.0176	40.02	.0167
Fresno	38.45	.0221	39.02	.0197
San Joaquin	38.07	.0241	38.78	.0207
San Bernardino-Riverside	39.71	.0175	39.92	.0169

a/ Labor cost per day: \$29.73 plus truck operating expenses calculated by the formula $TC = \$4.59 + 0.002378V_r$, where TC represents truck operating expense per route day and V_r represents the total volume handled per route expressed in labor units.

been experienced with route volumes at the pre-1956 levels. This amounts to a reduction in cost per unit of 12.5 per cent and, based on the sale of approximately 1.4 million quarts of milk per day to wholesale customers in the Los Angeles marketing area,[1] represents a saving in delivery costs of approximately $3,000 per delivery day in the Los Angeles area. Because of the proportionately greater increase in average volumes in the San Francisco and the Alameda-Contra Costa marketing areas, the estimated cost differences are more substantial, amounting to approximately 4/10 cent per quart. Since only slight changes were noted in either the average volume per stop or in average route volumes in the San Bernardino-Riverside marketing area, little differences in costs (less than 1/10 cent per quart) are shown.

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1/ Average daily sales for the period January 1 to April 30, 1960, based on a six-day delivery week.